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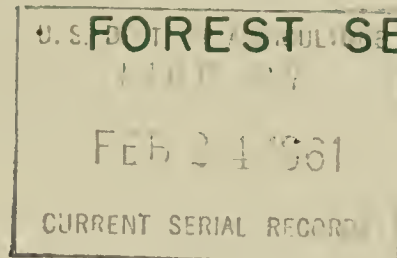
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TECHNICAL NOTES

LAKE STATES FOREST EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE · U.S. FOREST SERVICE

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No. 597



Mortality and Top Killing of Spruce-Fir Caused by
Repeated Budworm Defoliation

Beginning in 1955, annual surveys have followed the spread of the spruce budworm infestation of the spruce-fir type in northern Minnesota. In 1958, a new color variation was observed in some of the stands: They appeared gray instead of the brown usually found in heavy infestations. Investigation showed that these stands were not only sustaining heavy current feeding, but also had had heavy to complete defoliation for at least the previous 2 years. This condition, classed as severe defoliation, has intensified and increased in area each succeeding year. In 1960, 96,000 acres of spruce-fir type were mapped as severely defoliated.

Until this past season quantitative data on tree condition, such as top killing and tree mortality, were lacking, primarily because most of the severe defoliation was located in the remote canoe country where travel is restricted to canoe or float-equipped airplanes.

During the last week in September of 1960 a three-man crew traveled 185 miles by canoe across the border country and established eight paired plots in spruce-fir type to determine the volume of timber losses attributable to budworm defoliation. To reduce bias, the route was mapped from an airplane prior to the trip, and the areas of severe defoliation were noted. This information was transferred to timber survey maps, and approximate plot locations were chosen. Criteria for selection of a plot pair were that both plots had to be located in similar timber types and in contiguous forest stands. The circular plots varied in size from 1/7 acre to 1/3 acre, depending on tree density. Each plot had to be large enough to provide a sample of at least 80 susceptible trees 4 inches d.b.h. and larger.

All trees were tallied that (1) had a dead top of 2 or more feet or (2) had died within the past 2 years. Top killing was determined by binocular examination. Tree death was verified by examining the cambium. Dead trees were studied to discover whether they had been killed by the budworm. If the cause of death could not be ascribed to the budworm, the tree was tallied as having been killed by other causes.

Individual plot data revealed top killing as high as 78 percent and tree mortality as great as 2.4 cords per acre. The volume of each budworm-killed tree was based on the diameter at breast height and an estimate of the number of 100-inch sticks to a 3-inch top. These values, as shown in table 1, were converted to cordwood volume per acre by diameter classes.

Trees under 4 inches d.b.h. were tallied on one-quarter of the plot, the northwest quarter being arbitrarily chosen on all plots. Of these smaller trees, 6.5 percent were top killed, 11.9 percent were dead because of budworm defoliation, and an additional 8.9 percent mortality was due to other causes.

Many of the top-killed trees are now very near death. The fate of all the trees will be followed to determine trends in the deterioration of spruce-fir following a budworm epidemic.

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D. C. SCHMIEGE, Entomologist

Table 1.--Top killing and tree mortality in areas heavily infested by spruce budworm, 1960^{1/}

DBH (inches)	Species	Total trees : on plots	Percent of trees		Percent of trees killed by --		Cdwd. vol./acre of	
			top killed	:	Budworm	:	Other causes	: budworm-killed trees
4	Balsam fir W. spruce	334 4	22.5 0		6.0 0		5.4 25.0	0.024 0
5	Balsam fir W. spruce	367 5	34.9 0		6.8 20.0		4.1 0	.081 .005
6	Balsam fir W. spruce	217 7	48.4 0		4.6 0		3.7 0	.106 0
7	Balsam fir W. spruce	111 4	53.2 0		15.3 0		1.8 0	.262 0
8	Balsam fir W. spruce	56 6	66.1 0		8.9 16.7		5.4 0	.133 .021
9	Balsam fir W. spruce	18 8	72.2 0		5.6 0		11.1 0	.034 0
10	Balsam fir W. spruce	13 11	100.0 0		0 9.1		0 0	0 .060
11	Balsam fir W. spruce	12 4	83.3 0		0 0		8.3 0	0 0
12	Balsam fir W. spruce	9 0	100.0 0		0 0		0 0	0 0
13	Balsam fir W. spruce	6 2	83.3 0		16.7 0		0 0	.094 0
14 & up	Balsam fir W. spruce	2 8	100.0 0		0 0		0 0	0 0
Average per acre		364	37.9		6.9		4.1	.821

^{1/} Based on 16 plots of variable size totaling 3.31 acres. Plots are located in northern Minnesota.